IMU Characterizatoin–Static Test

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Abstract

This report briefly describes the experimental setup and conditions. Results are quoted are briefly discussed.

1 Test Setup and Conditions

The Crossbow IMU400–a solid state MEMS inertial measurement unit–was allowed to sit idle on the testing table. Rate data from the 6 axes–angular velocity (deg/s) for roll, pitch, yaw; and acceleration x, y, z (g)–were collected using the software provided by the IMU manufacturer (Gyroview, V 2.1). The room was NOT temperature controlled, but assumed to remain fairly constant at around 25C. Further, the internal temperature of the IMU is recorded; equilibrium temperature was approximately 40.4 C. The serial number of the model tested was 24662. Power was supplied at 20V, and data was collected at 20 Hz. The duration of the static test was about 18.5 hours.

2 Data Analysis and Results

The 20 Hz data was subsequently filtered with a low-pass filter with cutoff frequency 0.5 Hz. The filtered data was then subsampled at 1 Hz. Power spectral density was generated using the subsampled data with Matlab command pwelch with default settings (default overlap is length of data set divided by 2, Hamming windowed, etc.–for more info, consult matlab references.) The PSD's two main characteristics are the approximately -2 slope section, and the flat region. Line fitting was performed with some simple Matlab code written by me. A quick word on the fitting program: The basic idea behind is that it starts by fitting the higher frequency data on the PSD. The initial guess for this fit is the average value of the PSD. The line fitting continues toward smaller frequency until it detects a point beyond which no points in the PSD lie below the threshold. The threshold is defined as 3σ, where σ is the standard deviation of the subsampled data. These fits determined by Matlab contain all the necessary parameters describing the stochastic processes we wish to characterize.

3 Results

The following section contains a summary of the results. Note that σ_w refers to the "bias" (random walk) noise, and σ_r refers to the "rate" noise. Appropriate units for the quantities σ_r and σ_w have been chosen and are noted in the table below.

Gyro Axis	$\sigma_r \ (deg/s/Hz^{1/2})$	$\sigma_w \ (deg/s^{3/2})$
Roll	0.0218	6.9614e-005
Pitch	0.0212	2.9796e-005
Yaw	0.0227	1.3986e-004
Accel Axis	$\sigma_r \ (g/Hz^{1/2})$	$\sigma_w \ (g/s)$
X	4.2403e-005	1.7446e-006
Y	5.1481e-005	5.8887e-007
Z	0.0016	1.2205e-004

The figures below display the Matlab Output. Red line indicates the region of frequencies to which the flat line was fit, and the blue line indicates the approximately -2 slope fit.
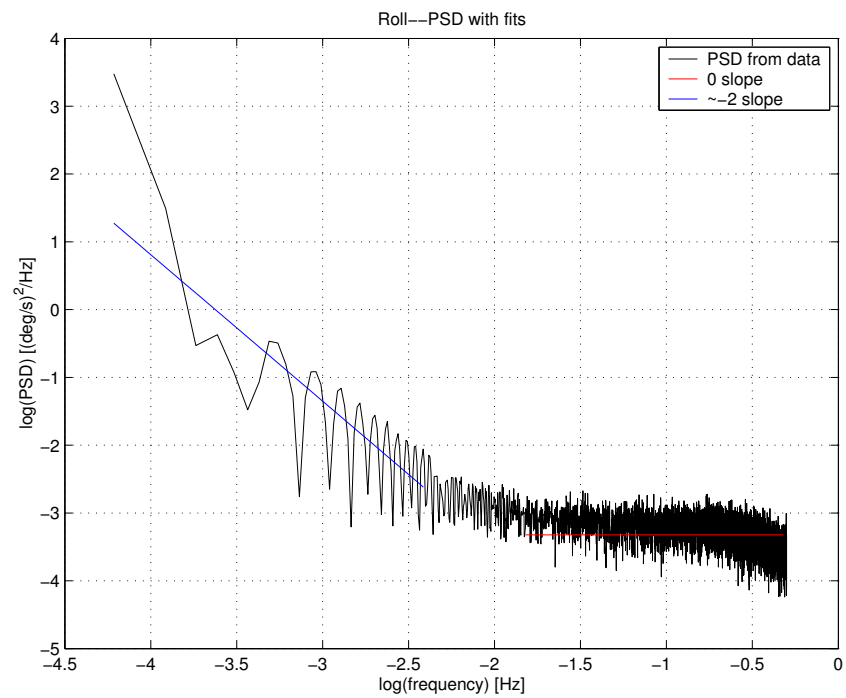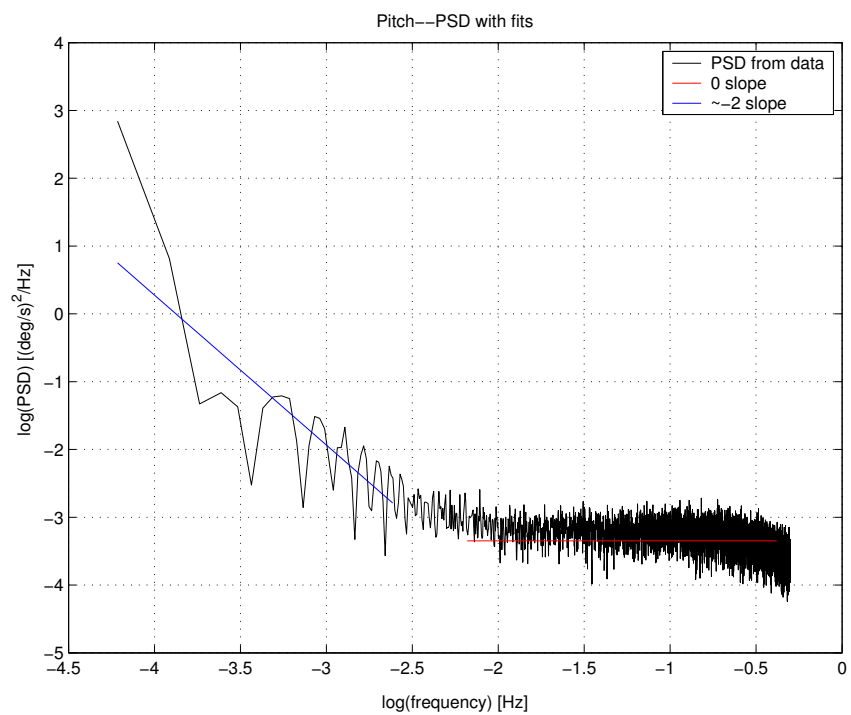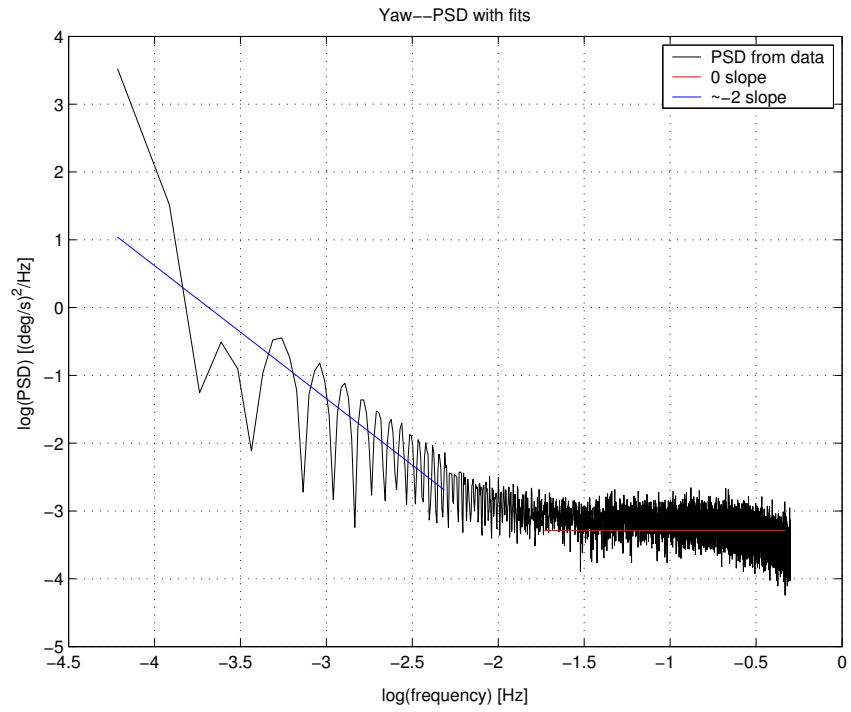
Figure 1: Roll
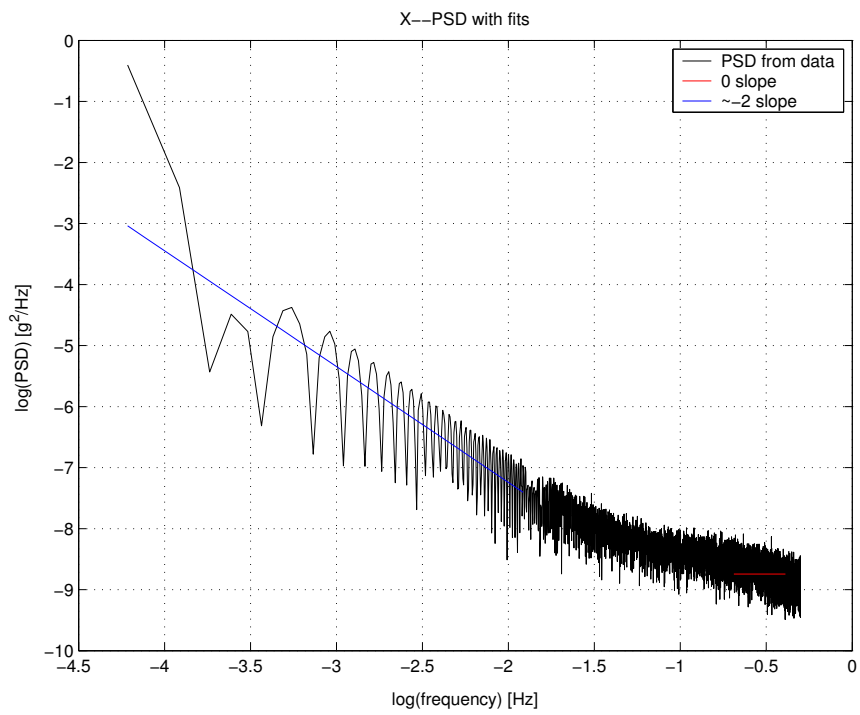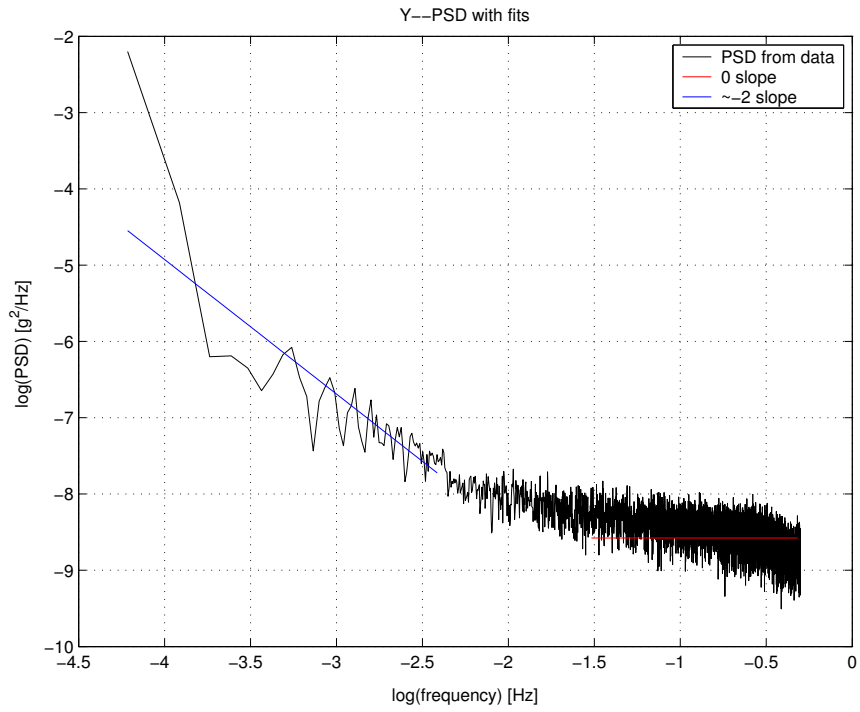

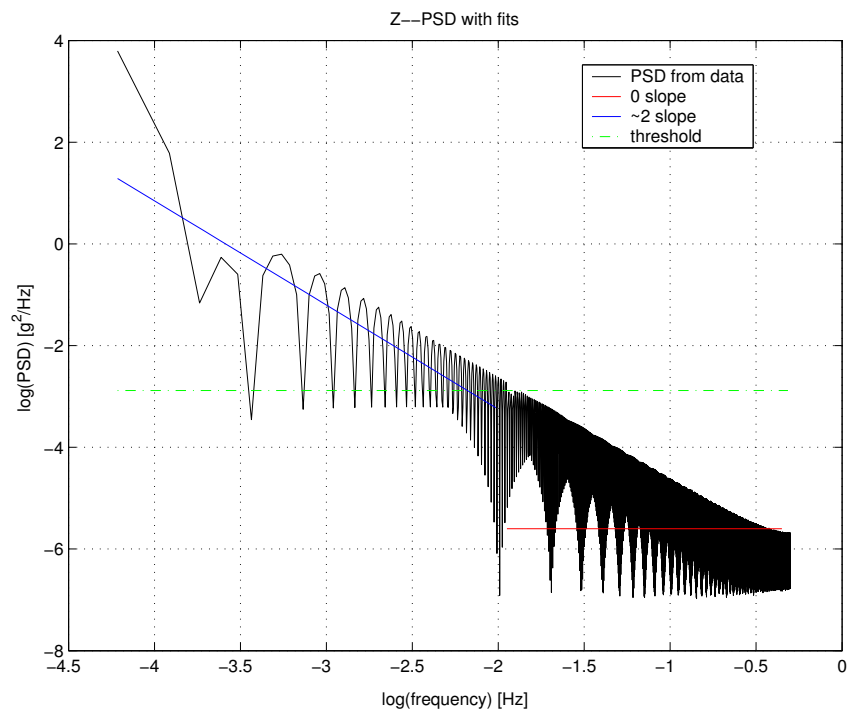Figure 2: Pitch

Figure 3: Yaw

Figure 4: X

Figure 5: Y

Figure 6: Z

4 (Brief) Discussion and Comments

The PSD for all three gyro axes look very similar upon visual inspection. The values for σ_r for all three gyro axes are in the same ballpark (without getting too technical on this claim) all within about 10 % of each other. We see slightly more scattered results for σ_w, however. The yaw and roll axes values for σ_w were found to differ by about a factor of 2. The effects of having finite roll off in our low-pass filter is noted around $10^{-0.5}$ Hz, where we see the flat region of the PSD start to dip down. This dip at the end of the PSD obviously lowers the value of the fitted line; the amount by which this dip changes calculated values for rate noise can be quickly estimated. The equation of the red line is given by y = -3.324. By visual inspection, we may think this line should be fit at a slightly higher value, about -3.124. Hence, the "updated" value for σ_r may differ by as much as a factor of $\sqrt{10^{-3.124}/10^{-3.314}} \simeq 1.25$. Conservative estimates, then, for the values of σ_r would be the values in the table in section 3 under roll, pitch, yaw MULTIPLIED BY 1.25. The accelerometer axes X and Z yielded data that was not as "nice" as the gyro data. The Z axis is, of course aligned with the gravitational vector, hence th "ugly" PSD. The PSD and data suggest that bias noise strongly dominantes rate noise at all measured frequencies along the Z-axis. A similar statement can be made for the X axis, all though we do see the rate noise dominates the bias noise at higher frequencies.